

Influence of calcium hydroxide intracanal medication on apical seal

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Abstract

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Aim The aim of this study was to determine the influence of calcium hydroxide intracanal medication and various techniques for its removal on the sealing ability of gutta-percha root fillings with a zinc oxide–eugenol sealer.

Methodology Eighty extracted mature human mandibular molar roots were divided into three groups of similar root-canal configuration. Calcium hydroxide paste was made by mixing calcium hydroxide powder with distilled water at a powder to liquid ratio of 1:1.25. After root canals were prepared and enlarged to a minimum of size 30 with the Profile 0.06 system, calcium hydroxide paste was placed in the canals of two groups, but no medication was placed in the control group. The intracanal calcium hydroxide was removed with two different techniques, 1 week after medication: K-files one size larger than the master apical file (MAF) were used with 2.5% NaOCl and 15% EDTA solutions in one group, whilst K-files the same

size as the MAF were used with 2.5% NaOCl solution in another group. Canals were obturated with gutta-percha and Tubli-Seal cement using the lateral condensation technique. The apical sealing-ability was assessed by dye leakage and cross-sections of the specimens were examined under a stereomicroscope. The dye-penetration level was measured and analyzed using Fisher's exact test and Duncan's multiple range test.

Results The calcium hydroxide-medicated groups showed significantly more dye leakage than the non-medicated control group ($P < 0.05$). However, there was no significant difference between the two calcium hydroxide-medicated groups ($P > 0.05$). The stereomicroscopic views showed a relatively uneven and thicker layer of sealer in the calcium hydroxide-medicated groups.

Conclusion Calcium hydroxide intracanal medication may increase apical leakage of gutta-percha root fillings when a zinc oxide–eugenol sealer is used.

Keywords: apical leakage, calcium hydroxide, intracanal medication, root-canal cement, zinc oxide–eugenol

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Introduction

Effective cleaning and shaping is the foundation of successful root-canal treatment. However, because of the complexity of root-canal systems, complete cleaning and shaping with presently available irrigants and instruments is difficult. When sufficient bacteria

remain within the system, they can proliferate and reinfect the root-canal space (Byström & Sundqvist 1981).

Intracanal medication has been advocated to further reduce the number of microorganisms between appointments. A wide range of chemicals have been used to disinfect the root-canal system including formocresol, cresatin, phenolic compounds, aldehydes, antibiotics, steroids, and calcium hydroxide.

Calcium hydroxide has been widely used as an intracanal medicament. Calcium hydroxide should be removed before root-canal filling, however, its complete removal is problematic, and some calcium hydroxide

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may be retained in the apical area (Guignes *et al.* 1991, Margelos *et al.* 1997, Lambrianidis *et al.* 1999).

Recently, Margelos *et al.* (1997) reported a possible problem caused by the interaction between calcium hydroxide and zinc oxide–eugenol sealers. There is a concern that, at the time of root-canal filling, the retention of calcium hydroxide on the canal wall might affect the quality of the seal and influence the prognosis of treatment. A few studies have reported on this problem with inconsistent findings. An apical leakage study (Porkaew *et al.* 1990) in teeth filled using lateral condensation demonstrated that teeth dressed with calcium hydroxide had significantly less leakage than those not medicated. A further study (Holland *et al.* 1995) supported this finding. However, these studies also noted that when calcium hydroxide dressing was retained in the canal, apical leakage increased with time. Recently, other studies (Kontakiotis *et al.* 1997, Wu *et al.* 1998) have described the possibility of false positive results occurring with previous dye-leakage studies using methylene blue dye, because it may lose its colour in contact with calcium hydroxide.

The purpose of this study was to determine the influence of calcium hydroxide intracanal medication, and various techniques for its removal on the apical sealing ability of gutta-percha root fillings when a zinc oxide–eugenol sealer was used.

Materials and methods

Preparation of specimens

Eighty extracted multi-rooted human mandibular molars were used. Calculus and soft tissue debris was removed with scalers and each tooth was sectioned

vertically with a disc to separate each root. After access cavity preparation, size 10–20 K-files were introduced to determine working lengths and apical foramen sizes.

Three separate roots with similar canal configuration were matched in a set, and 25 sets of roots were selected from 80 teeth; the remaining roots were discarded. The roots in each set were randomly divided into three groups A, B, and C of 25 roots each, so that the three groups had a similar root-canal configuration (Table 1). An additional six roots were used for negative and positive leakage controls.

All the root canals were prepared by one operator. Working lengths were established 1 mm short of the apical foramen, and size 10–20 K-files were used as initial apical files (IAF). The coronal one-third was flared with size 4–2 Gates Glidden burs and the apical two-thirds of the canals were instrumented sequentially with size 40–25, 0.06 ProFiles (Dentsply Maillefer, Ballaigues, Switzerland) at a constant speed of 300 r.p.m. in a crown-down manner. The apical region was then enlarged with size 20–30, 0.06 ProFiles until the master apical file (MAF) size was three sizes larger than the size of the IAF. Root canals were irrigated after each instrument, and 5 mL of 15% EDTA and 5 mL of 2.5% sodium hypochlorite (NaOCl) solutions were used alternately with a 25-gauge needle.

Calcium hydroxide paste was made by mixing D.S.P. GR reagent grade calcium hydroxide (Duksan Pure Chemical Co. Ltd., Ansan, Korea) with distilled water at a powder to liquid ratio of 1 : 1.25. After canals were dried with paper points, calcium hydroxide paste was placed in the canal with the use of a lentulo spiral filler in groups A and B; no medication was introduced in group C. The access cavities of all the roots were temporarily sealed

Table 1 Root-canal configurations of specimens in each group

Characteristics	Range			Total number of specimens
	1	2	3	
Canal curvature	0–10°	10–30°	30–60°	25
<i>n</i>	3	18	4	
Number of canal (coronal–apical)	1–1	1–2	2–2	25
<i>n</i>	16	4	5	
Apical foramen shape	Round	Ovoid		25
<i>n</i>	9	16		
Apical foramen size no.	10	15	20	25
<i>n</i>	5	12	8	
Master apical file size no.	25	30	35	25
<i>n</i>	0	17	8	

with gutta-percha and Cavit W (Espe, Seefeld, Germany). All the roots were stored at 37 °C at 100% relative humidity for 7 days.

After removing the temporary coronal restoration, two different techniques were used to remove the calcium hydroxide. In group A, after irrigation with 2.5 mL of 2.5% NaOCl and 5.0 mL of 15% EDTA solutions, canals were cleaned to the working length with a K-file one size larger than the MAF size with reaming motion, and step-back preparation was completed up to four sizes larger than the first file (Holland *et al.* 1995). Canals were irrigated again with 2.5 mL of 2.5% NaOCl. In group B, after irrigation with 2.5 mL of 2.5% NaOCl and 5.0 mL of distilled water, canals were instrumented to the working length with a K-file of MAF size (Margelos *et al.* 1997). Canals were irrigated again with 2.5 mL of 2.5% NaOCl. In group C, no irrigation or filing was completed.

After the canals were dried with paper points, a zinc oxide–eugenol sealer, Tubli-seal® (Kerr, Romulus, MI, USA) was applied and the canals obturated by lateral condensation of gutta-percha (DiaDent® gutta-percha points, DiaDent Group International Inc., Chongju, Korea) with the exception of three positive leakage controls. Buccolingual and mesiodistal radiographs were taken in order to confirm the root-canal fillings were at length and were dense.

Dye-leakage test

The access cavity of each root was filled with a light-curing composite resin (Metafil CX, Sun Medical Co. Ltd., Moriyama, Japan). All the specimens, except the negative leakage controls, were coated with nail varnish on all but a 1-mm area around the apex. Three roots of the negative leakage controls were completely coated with nail varnish. All the roots were suspended on base-plate wax and the apical 3 mm of each was dipped in India ink (Winsor & Newton Ink, London, UK) and incubated at 37 °C and 100% humidity for 14 days.

Evaluation of apical leakage

All the specimens were sectioned horizontally at 1, 2, 3, 4, and 5 mm from the root apex with a microtome (Isomet, Buehler, Lake Bluff, IL, USA).

Linear measurements of apical leakage were recorded with a stereomicroscope (SZ40, Olympus Optical Co. Ltd., Tokyo, Japan) to evaluate the dye-penetration depth. The number of specimens with leakage was counted at each section level.

Statistical analysis

Fisher's exact test was used to determine the difference of the number of specimens at each leakage level amongst the three groups. Duncan's multiple range test was also adapted for a post hoc test. Corresponding *P*-values less than 0.05 were considered significant.

Results

Thirty specimens from 10 sets that had cracks in one or more of the three roots were excluded from the results.

The number of specimen with leakage at each level is shown in Table 2. Specimens in calcium hydroxide medicated groups A and B, had the greatest frequency of apical leakage at the 2 mm level, whilst group C, the control group, had greatest frequency at 1 mm level. Calcium hydroxide-medicated groups A and B, were shown to induce significantly more apical leakage than the non-medicated control group C ($P < 0.05$). However, there was no statistical difference between group A, the EDTA and NaOCl irrigation group; and group B, the NaOCl irrigation group.

Calcium hydroxide-medicated canals had sealer of uneven thickness and non-homogenous appearance whilst non-medicated ones had set sealer of relatively even thickness and homogenous appearance (Fig. 1). Microscopic views showed some cracks and voids in

Table 2 Number of specimens with leakage at each level

	<i>n</i>	Level from the apex (mm)					
		0	1	2	3	4	5
Group A (Ca(OH) ₂ medication/EDTA and NaOCl irrigation)	15	0	1	8	3	1	2
Group B (Ca(OH) ₂ medication/NaOCl irrigation)	15	0	3	8	2	0	2
Group C* (control, no medication)	15	1	9	5	0	0	0

*Significantly different from other groups ($P < 0.05$).

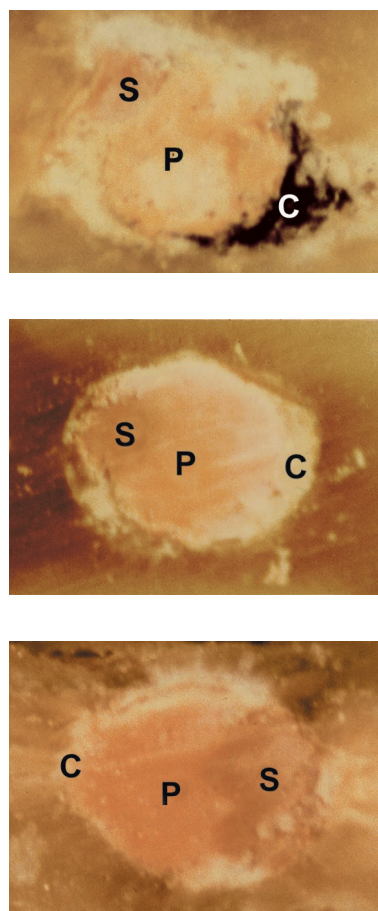


Figure 1 Stereomicroscopic appearances of specimens. A: a 3-mm level specimen from group A; B: a 5-mm level specimen from group B; and C: a 3-mm level specimen from group C. Specimens from groups A and B show uneven thickness and non-homogenous appearances of set root-canal cement. Root-canal cement (c) between primary gutta-percha cone (p) and canal wall opposite side of secondary cone (s) appears thicker in calcium hydroxide-medicated canals (A, B) than in control (C).

the sealer around the gutta-percha canal filling in the calcium hydroxide-medicated groups.

Discussion

In the present study, extracted whole mandibular molar roots were used as the experimental model. Because root-canal morphology can affect the application and removal of calcium hydroxide and canal obturation, distribution of roots with each group was made on the basis of root and canal shape.

Because it is difficult to remove calcium hydroxide paste completely from the root canal (Guignes *et al.* 1991, Margelos *et al.* 1997, Lambrianidis *et al.* 1999), there is a need to determine whether the remaining calcium hydroxide paste has any beneficial or adverse effect on the filling. There have been several studies regarding the influence of remaining calcium hydroxide on the apical seal of root-canal fillings. Porkaew *et al.* (1990) and Holland *et al.* (1995) reported that apical leakage was less in teeth that received calcium hydroxide dressings than in non-medicated control teeth. Holland *et al.* (1995) explained the reduced leakage in calcium hydroxide-medicated teeth on the basis that the residual calcium hydroxide was incorporated into the sealer during obturation, which caused a decrease in the permeability of the sealer itself or that calcium hydroxide was transported or mechanically forced into the dentinal tubules, blocking them off and decreasing dentinal permeability. They also suggested that the improved seal with plugs of calcium hydroxide was due to the fact that the plug provides a stop or matrix against which the gutta-percha and sealer may be condensed more effectively.

However, in the present study, calcium hydroxide-medicated root canals showed significantly more apical leakage than ones without medication. Because calcium hydroxide cannot be removed completely from the canal, it is likely that the remaining calcium hydroxide may interfere with the sealability of fillings when a zinc oxide–eugenol sealer is used. A number of explanations may account for the difference between the present study and those of Holland *et al.* (1995). Firstly, it is not likely that a decrease in dentinal permeability will lead to a decrease in apical leakage. Leakage at the apex occurs between the root-canal wall and the sealer, between the sealer and the gutta-percha, or within the sealer itself. In the present apical-leakage study, all the specimens were coated with nail varnish on their root surface to exclude any possible leakage through the dentine surface to leave only apical pathways. Secondly, when calcium hydroxide was mixed with zinc oxide–eugenol sealer, a calcium hydroxide–eugenol compound was reported to be produced, which was more soluble, less sealing had a thicker film-thickness and higher water-sorption value than the original sealer (Park *et al.* 1999). In another study (Park 1999), calcium hydroxide and zinc oxide–eugenol were shown to form calcium eugenolate, or that calcium bonds to eugenol by an ionic bond which can be broken when water is present. These reports imply that, when a zinc oxide–eugenol sealer is used, calcium eugenolate is formed which weakens the sealer in the long term.

Even though there is no reported technique that can remove calcium hydroxide completely from the canal (Lambrianidis *et al.* 1999), root-canal irrigation with NaOCl and EDTA solutions have given better results than NaOCl alone (Margelos *et al.* 1997, Çalt & Serper 1999). However, in the present study, there was no significant difference in leakage between these two groups. A combined approach to remove calcium hydroxide from the canal with irrigation and an instrumentation demonstrated no difference in the apical seal between K-files one size larger than the MAF, and K-files of the same size as the MAF. Holland *et al.* (1995) also reported similar results with size 40–70 files.

Calcium hydroxide has been reported to have a decolourizing effect on methylene blue dye (Kontakiotis *et al.* 1997). Wu *et al.* (1998) also studied the decolourizing effect of six dental filling materials on 1% methylene blue dye, and found that calcium hydroxide had decolourized the dye by 74%. The decolourizing effect of calcium hydroxide is related to its high alkalinity and this varies according to its form, that is, paste, cone or sealer (Esberard *et al.* 1996, Wu *et al.* 1998, Çalt *et al.* 1999, Economides *et al.* 1999). On the contrary, India ink was not shown to be decolourized by calcium hydroxide (Çalışkan *et al.* 1998). This might be one of the possible explanations for the results of the present study using India ink being different from previous studies with methylene blue (Porkaew *et al.* 1990, Holland *et al.* 1995).

India ink particles are known to be much larger than methylene blue, but are still small enough to penetrate cracks within root-canal sealers (Yoshikawa *et al.* 1997). Ahlberg *et al.* (1995) compared linear leakage patterns of methylene blue and India ink, and showed that methylene blue penetrated more deeply and with more variance. This penetration-depth difference between methylene blue dye and India ink might be another possible explanation for differences between the present study using India ink and previous studies using methylene blue.

In the present study, the set sealer showed relatively uneven thickness, some cracks and voids in the calcium hydroxide-medicated canals. These appearances are in agreement with other studies (Margelos *et al.* 1997, Park *et al.* 1999) and can be explained by the report (Margelos *et al.* 1997) that a faster setting of sealer prevented full sealing of gutta-percha, and this may be related to the thicker appearance of the sealer in the present study. The present appearance of a thicker sealer is also in accordance with the finding of Çalt & Serper (1999) that when calcium hydroxide was left on the root-canal surface, the sealer could not penetrate into dentinal tubules.

Conclusion

Under the condition of this study, calcium hydroxide-medicated canals showed significantly more apical dye-leakage than the non-medicated ones.

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